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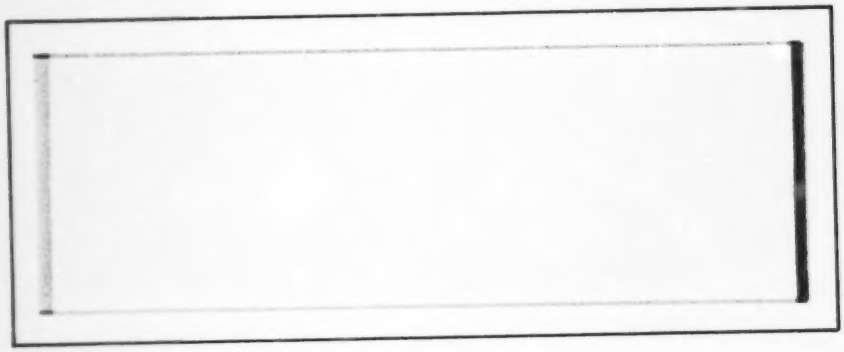

WORKING PAPER

Marketing and Economics Branch

Direction générale de la commercialisation et de l'économie

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ECONOMIC IMPACT OF ANAPLASMOSIS IN CANADA

(Working Paper 10/84)

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FOREWORD

On July 14, 1983 an outbreak of the foreign cattle disease anaplasmosis was detected on a ranch in southern Saskatchewan. The outbreak triggered Agriculture Canada's emergency animal disease eradication program designed to quickly "stamp-out" the disease. In August 1983 Dr. W.S. Bulmer, Associate Director, Disease Control, Animal Health Division at Agriculture Canada asked the Food Regulation Analysis Section of Marketing and Economics Branch to undertake an economic impact study of the outbreak in order to provide necessary economic advice during the course of the outbreak, as well as a thorough economic evaluation of available control options.

On February 9, 1984 the quarantine period ended signalling an end to the emergency situation, although monitoring will continue through 1984 and beyond in order to ensure that no futher cases of the disease occur. This study represents the researcher's findings concerning the impact of the strategy employed to combat the outbreak. It represents one of the first complete Canadian economic studies in the area of foreign animal disease control.

THE AUTHOR

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Full responsibility for the use of the data and contents of the report, of course, remains with the author.

TABLE OF CONTENTS

PAGE

ACKNOWLEDGEMENTS i

FIGURES AND TABLES iii

EXECUTIVE SUMMARY iv

1. Introduction 1

2. Anaplasmosis and its Control 2

2.1 Nature of the Disease 2
2.2 Spread and Epidemiology of Anaplasmosis 4
2.3 History of Anaplasmosis in Canada 7
2.4 Distribution of Anaplasmosis 9

2.4.1 Anaplasmosis in the United States 9
2.4.2 Anaplasmosis in Other Countries 11

2.5 Control Practices 12

3. Framework of Benefit-Cost Analysis 16

4. Methodology and Data Requirements 22

5. Case Review, 1983 Outbreak 26

6. Control Alternatives and Results 32

6.1 Eradication, Test and Slaughter 33
6.2 Eradication, Test and Treat 49
6.3 Endemic Anaplasmosis, No Public Control 54

7. Evaluation of Control Alternatives 64

7.1 Sensitivity of Results 66
7.2 Observations and Suggestions 68

8. Summary and Conclusion 71

FOOTNOTES 73

GLOSSARY OF TERMS 76

FIGURES AND TABLES

PAGE

FIGURES

1 Location of Anaplasmosis Outbreak Area 27

2 Control Strategy - Test and Slaughter 35

3 Control Strategy - Test and Treat 50

4 Incidence of Anaplasmosis by Census Districts 56

TABLES

1 Data on Herds Infected with Anaplasmosis 31

2 Outbreak Cost Summary 37

3 Compensation Costs 38

4 Salary Cost Summary 39

5 Estimate of the Number of Cattle Affected Should Anaplasmosis Become Endemic in Canada 59

6 Estimated Losses Associated with Clinical Cases of Anaplasmosis 60

7 Evaluation of Control Policies in Terms of Discounted Net Present Values and Benefit-Cost Ratios 65

EXECUTIVE SUMMARY

In July 1983 an outbreak of the cattle disease anaplasmosis occurred in the southwestern part of Saskatchewan. At the request of Health of Animals Directorate, Food Production and Inspection Branch an economic evaluation was initiated of the program used to control the outbreak. The fact that this study was initiated while the outbreak was still in progress facilitated the collection of the necessary economic data for this report.

This study is a benefit-cost study which sets out to answer the following questions:

1. what would be the economic impact should anaplasmosis become established in Canada;

2. what are the relative costs and benefits of alternative control strategies; and

3. what is the most cost-effective method of dealing with future outbreaks?

In addition to answering these questions, the study discusses the disease and its history in Canada. It also discusses the benefit-cost technique and its application to the animal health area. A case summary of the 1983 outbreak is also provided.

Anaplasmosis is a blood disease mainly affecting cattle which is spread by ticks and other biting insects. While Canada is free of the disease it is well established in most of the states of the United States including the border states of Montana and Idaho.

The Saskatchewan outbreak of anaplasmosis was the third outbreak of this disease in Canada and is the largest to date. The control of the Saskatchewan outbreak cost $986 thousand and resulted in the slaughter of 1588 animals. By far the largest cost (approximately 65%) in controlling the outbreak was the payment of compensation to herd owners for animals sent for slaughter.

The study evaluates two feasible eradication options, namely the test and slaughter option (the current method used) and the test and treat option as well as the no public control option. The study concludes that public control of anaplasmosis, as opposed to allowing the disease to invade Canada, is unquestionably justified on economic grounds with a benefit-cost ratio of over 17 to 1. Although both control options are economically justified, the test and treat option can only be used after the insect season is over, which limits its applicability. When it is useable, however, it is less costly than the test and slaughter option.

A number of observations and suggestions emerged as a result of this study. One suggestion is that authority be obtained under the Animal Disease and Protection Act to pay for treatment costs, thus permitting the use of the test and treat option, when feasible. The study points out that the cost of controlling anaplasmosis will depend on the frequency and size of future outbreaks. A number of steps can be taken which could reduce the frequency and/or size of future outbreaks.

The study demonstrates the usefulness of benefit-cost analysis when applied to the evaluation of program options in the area of animal health. Benefit-cost analysis is particularly valid when evaluating an actual experience with a program such as was the case with controlling the anaplasmosis outbreak.

1. Introduction

This study was initiated following an outbreak of the disease anaplasmosis in July 1983 in the southwestern part of Saskatchewan. Anaplasmosis is a blood disease affecting cattle that is mainly spread by ticks and other biting insects. Canada's cattle population has been free of this disease which is present in most of the warmer climate countries of the world and in most of the states in the United States. This latest outbreak is the third outbreak of the disease in Canada in the past 16 years and is the largest to date.

The Health of Animals Directorate, Food Production and Inspection Branch of Agriculture Canada has the responsibility for controlling outbreaks of foreign animal diseases. This study was initiated at their request with a view to defining and estimating the potential economic impact of anaplasmosis and of technologically available control strategies under the conditions of the introduction of the disease into Canada. Its objective is to provide the "tools" with which to make society-level decisions about the economic aspects of control strategies against animal diseases.

Anaplasmosis is endemic in the United States, including states which border on Canada. It is highly likely that outbreaks of anaplasmosis will continue from time to time in Canada. With

this in mind, the study was conducted with the following major objectives:

a) to estimate the economic impact for Canada should anaplasmosis become endemic;

b) to estimate the relative costs and benefits of alternative control strategies against anaplasmosis in Canada; and

c) to provide guidelines to the Health of Animals Directorate for the most cost-effective method of dealing with future outbreaks.

The study is divided into three broad areas. The first area is a discussion of the disease and its control. This is followed by an outline of benefit-cost analysis and how it is applied in this study. Finally there is an analysis of the data, the results and conclusion. The study will use as its data source the evidence from the 1983 outbreak in Saskatchewan. This will be supplemented by data based on the U.S. experience with anaplasmosis.

2. Anaplasmosis and its Control

2.1 Nature of the Disease

Anaplasmosis is an infectious, non-contagious transmissible disease of cattle caused by the microscopic parasite,

Anaplasma marginale, which lives in the red blood cells of cattle. The main characteristics of the disease are anaemia, jaundice and a decline in physical condition. The severity of the disease varies with age. Calves undergo mild infection which usually is not observable. In yearlings, the disease is more severe but the animals recover. Greatest severity occurs in cattle two years of age and older, with marked anaemia developing and mortality ranging from 20-50 percent of affected animals. The degree of serious infection in bulls is usually higher than in cows.

In the acute form symptoms include elevated body temperature, depression, lack of appetite, accelerated respiration, increased pulse rate, constipation, atony of the rumen, and reduced milk flow. As red blood cells are destroyed, anaemia develops to a point where pallor and jaundice are apparent in the skin of the eyelids, teats and udder. At this stage, slight exertion may cause death due to lack of oxygen. The disease leads to economic loss due to severe weight loss, poor reproductive ability, abortion, decreased milk production, and sometimes death of the infected animal. Some cattle never return to normal weight or full milk production.

In the chronic form, mainly in calves and yearlings, there is temporary depression, loss of appetite, roughness of

hair coat, generally poor condition, and sometimes a slight mucous and pus discharge from the eyes and nose. Most mild cases of the disease are unobserved. Animals which recover from the disease remain carriers and thus act as reservoirs of the disease. The carrier state, however, can be eliminated by treating the animals with oxytetracycline(1). Evidence from the United States from affected herds is that only 1-2 percent of the cattle show signs of being ill (clinical cases).

Diagnosis of anaplasmosis is initially based on the recognition of seasonal anaemia and jaundice (mainly in summer). A positive diagnosis depends on evidence of anaplasma bodies by microscopic examination of stained blood smears coupled with a positive complement-fixation blood test. In experiments, following inoculation of infected blood into susceptible animals, it usually takes from 17-45 days for the disease to develop, although longer incubation periods have been reported.

2.2 Spread and Epidemiology of Anaplasmosis

Three requirements are necessary for the spread of anaplasmosis, these are: (1) the disease agent, Anaplasma marginale, (2) susceptible hosts, and (3) an agent (vector) to transmit the disease from one host to another.

(1) Disease Agent

The disease agent can be introduced into Canada in several ways. These include imports of infected cattle or northward spread of the disease from the United States. Cloven-hoofed animals such as sheep, deer, elk and antelope can be carriers of the disease and infected animals may stray into Canada from the United States and lead to infection of Canadian cattle. The disease is present in certain border states, particularly Montana. The disease could be spread from an association along the Canada-U.S. border of an infected U.S. herd with a Canadian herd.

(2) Susceptible Hosts

The entire Canadian cattle population has no natural immunity to the disease and consequently is at risk to the disease.

(3) Vector to Transmit the Disease

Anaplasmosis is spread by a transfer of blood from an infected animal to a susceptible one. Transmission of the disease may result from a mechanical transfer or a biological transfer. Mechanical transfer can be by way of biting insects such as horseflies, stableflies, horn flies, mosquitoes or by man carrying out common surgical operations such as a dehorning, castration, or vaccination. Mechanical transmission takes place only

when the disease organism is exchanged rapidly, within minutes. There are certain biological vectors such as the ticks Dermacentor occidentalis and Dermacentor andersoni. These ticks can harbour the infective agent and transmit the disease while feeding on cattle. It is suspected that the disease can survive in an unfed tick for a period of up to 6 years.

Epidemiological studies of anaplasmosis conducted in northwestern states of the United States provide information as to areas in which the disease is likely to spread and to become endemic in Canada, should it not be controlled in this country. Anaplasmosis is primarily observed in beef cattle and is only occasionaly observed in dairy cattle and feed lots.(2) An epidemiological study in Oregon noted that anaplasmosis is generally limited to arid sagebrush areas(3). A study in Idaho and Washington State also noted that herds on open semi-arid grazing areas had a higher incidence of anaplasmosis than did herds held year-round on forest range areas(2). The Oregon study noted that over the years the disease has had ample opportunity to invade adjacent areas but has not done so. The reason for this observation is not presently known. One theory is that the semi-arid and arid sagebrush areas are conducive to the development of the principal vector in the area, Dermacentor andersoni. It is known that Dermacentor andersoni larvae and nymphs parasitize mainly

small rodent species[2]. These hosts are more prevalent in the sage brush areas. The Oregon study also concluded that little relationship appeared to exist between the prevalence of clinical anaplasmosis and the prevalence of horse flies, deer flies or mosquitoes.

It has been noted that wild ruminants such as deer and elk are potential reservoirs of Anaplasma marginale[2]. However, epidemiological studies indicate that in northwestern states deer and elk are not important reservoir hosts of A. marginale nor contribute in any significant way to the spread of the disease[3][4].

2.3 History of Anaplasmosis in Canada

Canada experienced its first outbreak of anaplasmosis in August 1968[5]. The outbreak took place in the municipality of Marchand located about 25 miles southeast of Winnipeg, Manitoba. There were 16 herds in the area with a total of 1,717 head of cattle. The majority of the infected cattle were found in one herd, while four other herds had at least one infected animal. Of the 1,717 animals tested, 232 reactors were detected and slaughtered, 225 cattle slaughtered were from one herd.

It is believed that the disease was introduced into the main herd when 9 bulls were purchased from the state of Kansas in the spring of 1967. There was some evidence to suspect that this herd showed signs of the disease in 1967.

Total compensation paid for the 232 destroyed animals was $55,943 of which $27,046 was retrieved from the salvage value of the carcasses. The net cost of the outbreak was $28,897 in compensation.

The second outbreak of anaplasmosis occurred in Quebec in 1979[6]. In August of that year 18 Hereford cattle were bought at an auction held in the state of Connecticut. When they were imported into Canada at Rock Island, Quebec they appeared to be healthy. However, soon after importation five of the cattle exhibited acute hemolytic anaemia, depression, fever and anorexia, and eventually died. Of the remaining 13 imported cattle, 11 were slaughtered because they had positive or suspicious anaplasma titres. Two other cattle were quarantined and later released.

The cost of this second outbreak in terms of compensation was $18,315, with a carcass salvage value of $2,927 which resulted in a net cost to the government of $15,388.

The third outbreak was detected in July 1983 on a ranch in Southwestern Saskatchewan, near the Montana border. The source of the outbreak has not been firmly established, however, it is believed that it resulted from a migration of the disease across the border from the state of Montana. This may have resulted from the migration of infected big

game animals across the border or a chance association along the Canada-U.S. border of Canadian cattle with infected U.S. cattle. Due to the extent of the outbreak it is believed that the outbreak had gone undetected for some time.

In total 1486 cattle, 101 sheep and 1 goat were destroyed in controlling the outbreak. Compensation paid was $965,945, with a carcass salvage value of $330,462 for a net pay-out by the government of $635,483. This outbreak was by far the most costly to date.

2.4 Distribution of Anaplasmosis

2.4.1 Anaplasmosis in the United States

Anaplasmosis is believed to be endemic in at least 40 of the 50 states of the United States[7]. In 1973, McCallon[8] conducted a survey to determine the prevalence rates which were found to range from a low of 1% in several northeastern and northcentral states to a high of 31% in cattle in California. His data indicate that there are three areas in which the prevalence of anaplasmosis is above 10%. They are: 1) the southeastern states including Florida, Georgia, Alabama, Mississippi, Louisiana, South Carolina, North Carolina, Tennessee, Arkansas, eastern Texas, eastern Oklahoma and Missouri;

2) the intermountain states including Montana, Wyoming, northern Colorado, northern Utah, southern Idaho, and eastern Oregon; and 3) the pacific coast states of California and southwestern Oregon.

The literature suggests that the epidemiology of the disease differs between each of the above three areas.(7) The Midwest and the Southeast are often considered together epidemiologically. Anaplasmosis in these regions is spread from infected cattle by biting flies. It is believed that the tick as a vector is relatively unimportant in these regions and that there are no wildlife reservoirs in these areas. In California, and possibly the adjacent states of Nevada and Oregon, the principal vector is believed to be the tick Dermacentor occidentalis (Pacific Coast tick) and a high percentage of resident deer (Columbian black-tailed deer) in this area are carriers of the infection. The epidemiology of anaplasmosis in the inter-mountain states is not well-defined although it is believed that the principal vector is the wood tick Dermacentor andersoni. While the disease has been shown to exist in some wildlife in the area it is not believed to be a significant reservoir of the disease nor a major method of transmission of the disease.

The situation in the intermountain states is of special interest as this area is immediately south of the prairie provinces and the epidemiology of anaplasmosis in these states would likely be similar to that in Canada should the disease become endemic in this country. In his 1973 survey, McCallon found a 16% prevalence rate of anaplasmosis in Idaho. The areas of highest prevalence were the southeastern and southwestern portions of the state and the lowest prevalence was found in the northern portion of the state. For Montana, the 1973 survey showed a prevalence rate of 11%. More recent testing information from Montana for the years 1980-83 shows an average infection rate of 2.4%.(9) It is felt that the infection level in the region just below the Canadian border is very low, well below 5%(9).

2.4.2 Anaplasmosis in Other Countries

Anaplasmosis is widely distributed in the warmer parts of the world, and is spreading slowly into temperate areas as cattle with latent infections are transported there.

Anaplasmosis is present in most countries of North and South America with the notable exception of Canada. It is also present in most countries in Africa and in Australia. Most countries of Europe

are free of anaplasmosis although low incidences of the disease have been reported in Portugal, Bulgaria, Greece, Turkey and the U.S.S.R.

2.5 Control Practices

The primary method of controlling anaplasmosis is to prevent its entry into Canada. This is accomplished through the work of the Animal Health Directorate of Agriculture Canada which, operating under the authority of the Animal Disease and Protection Act, controls and regulates the importation of animal and animal products. Countries that are largely self-sufficient in meat products or net exporters, as Canada is at present, can afford to restrict imports of animals and animal products in order to prevent entry of foreign animal diseases. The control of imports was primarily established to prevent the entry of serious and costly animal diseases such as foot-and-mouth disease, rinderpest and african swine fever. This same control system is used to prevent the entry into Canada of less serious animal diseases such as anaplasmosis.

All livestock and poultry entering Canada are subject to inspection at federal quarantine and/or inspection ports along the Canada-United States border, the Atlantic and Pacific seaboards, the St. Lawrence Seaway System, and at international airports. Imports of animals are allowed only from countries where serious foreign diseases are

adequately controlled. All imported animals are subject to certification, inspection or quarantine on arrival in Canada. The regulations concerning importation of animals vary somewhat depending on whether the animal was imported from the United States or some other country.

The control of imported animals is an integral part of Canada's National Animal Health Program. The animal health program can be divided into three interdependent functions:

1. The detection and prevention of animal disease entry into Canada.

2. The control of animal disease spread within Canada, which includes the eradication of animal diseases.

3. The domestic and international monitoring of animal diseases including all aspects of veterinary research and preventive medicine, and the domestic inspection and health certification of animals, herds, flocks and regions of Canada.

These functions are carried out by a staff of approximately 980 persons and a budget of $31.5 million. The activities under the animal health program are conducted through the operation of 116 district offices, 7 regional offices and 8 federal veterinary laboratories. The detection and

prevention of animal disease entry is carried out through the manning of 96 Canada/U.S.A. border ports of entry, eleven major international airports and eleven major international seaports. Approximately 234 person years are allocated to the prevention and detection of animal disease entry into Canada. This includes not only inspection activities but diagnosis and research as well.

The regulations concerning anaplasmosis under the Animal Disease and Protection Act require, on imports from the United States, a certificate signed by a veterinarian certifying that a test for anaplasmosis performed on the animal within 30 days of the date of importation was negative. In addition, the veterinarian must certify that all animals in the herd of origin showed no evidence of anaplasmosis within 30 days prior to the importation date or that the herd of origin proved negative to a test for anaplasmosis performed within one year prior to the data of importation(10). This certificate is not required if the animal is imported for immediate slaughter (within 4 days) at an establishment registered under the Meat Inspection Act. For the period November 1982 to October 1983 a total of 7,672 cattle were imported which required an anaplasmosis test.

In the event that an outbreak of a foreign animal disease, such as anaplasmosis occurs, Canada's control policy is to "stamp out" under a test and slaughter policy. The policy can be summarized as follows:

a) quarantine of infected and exposed premises;

b) testing of all infected and exposed herds and slaughter of all animals which react positively to the test;

c) payment of indemnities for animals destroyed in the course of the eradication program based on the market value of the animals.

In the case of anaplasmosis, an alternate eradication strategy which could be used is a "test and treat" policy. This policy is similar to the test and slaughter policy except that animals which are positive reactors are first treated with oxytetracycline, an antibiotic drug. If 90 days after the treatment the animals no longer test out positive then they are released from quarantine, otherwise they are sent for slaughter. This policy is only feasible during the season when ticks are no longer active as treatment has not been found to be effective during the season when vectors are active. Unfortunately this strategy is not practical at present as current legislation does not provide the authority to pay for the treatment costs.

3. Framework of Benefit-Cost Analysis

Benefit-cost analysis (synonymous with cost-benefit) is a method of evaluating the relative merits of alternative public investment projects in order that society as a whole may achieve efficient allocation of resources. This is done by measuring and comparing, where possible, the flows of benefits and costs generated by alternative projects over significant time spans. The object is not only to measure the financial costs and benefits of those directly involved in the projects (the direct benefits and costs) but also the wider social costs and benefits including those not directly concerned (the "consequential" effects).

The objective of benefit-cost analysis is to compare social benefits and costs of public investment projects or programs using a common measuring rod: dollars and cents. To the extent that different investment programs can be measured in money terms, benefit-cost analysis reduces the problem of trade-offs between different programs to a numerical one. That is, to assess whether or not a given program is worth doing, the resources necessary to implement and continue the program are compared with the improvement in the welfare of society that is likely to result. If the value of the resources used is less than that of benefits derived, the program may be judged socially and economically beneficial, and given the availability of funds and the absence of alternatives yielding higher net social benefits, the program may be undertaken. In

addition to deciding whether or not a program is simply worth doing, benefit-cost analysis is also useful in choosing the best program from various alternatives which are designed to achieve a common objective.

An important distinction must be made between those effects of public programs which increase total production and consumption opportunities in the economy, and those whose impact is to redistribute such opportunities from one group or region in the country to another. The effect of many government programs is not exclusively to increase global production possibilities or to redistribute them, but some combination of the two. The main focus of benefit-cost analysis is on the first type of impact, known as the efficiency or allocative impact of a program. The second type of impact is termed the non-allocative impact of a program.

Criteria for Project Investment Evaluation

Once the benefits and costs expected to result from investing funds in a given program have been properly measured, they must be compared with each other to determine which projects are the most desirable. There are several decision rules by which programs can be evaluated. The most common are net present value, benefit-cost ratio and the internal rate of return. Subject to the availability of funds, programs should generally be undertaken if they yield positive net present values,

benefit-cost ratios exceeding unity, or internal rates of return greater than the social rate of discount.

The net present value of a program is determined by subtracting the present value of program costs from the present value of benefits. The net present value (NPV) is defined by the formula:

$$NPV = \sum_{t=0}^{T} \frac{B_t - C_t}{(1+i)^t}$$

where B_t is the program benefits in year t, C_t is the costs in year t, i is the discount rate, and T is the last year for which benefits and costs are computed.

The benefit-cost ratio is determined by computing the ratio of discounted benefits to discounted costs. The formula for the benefit-cost ratio is:

$$B/C = \frac{\text{Present Value of Benefits}}{\text{Present Value of Costs}} = \frac{\sum_{t=0}^{T} \frac{B_t}{(1+i)^t}}{\sum_{t=0}^{T} \frac{C_t}{(1+i)^t}}$$

where T, t, B_t, C_t and i are as defined above.

The internal rate of return is the discount rate of return which equates the present value of benefits and the present value of costs. The formula for computing the internal rate of return is as follows:

$$IRR = \sum_{t=0}^{T} \frac{B_t - C_t}{(1 + r)^t} = 0$$

where T, t, B_t and C_t are as defined above and r is the internal rate of return to be calculated.

The Social Rate of Discount

The benefits and costs of investments may be realized over different time periods, and such differences in time periods affect the comparability of benefits and costs and hence, the desirability of projects. Society is not indifferent between benefits of a public investment or project which are realized immediately and benefits or costs in any future period as each dollar of future benefits or costs is valued less highly than each dollar of benefits or costs occuring in the present. For this reason, costs incurred and benefits derived at different periods must be reduced to some common point in time, usually the present, before they can be compared with each other. To allow for these welfare costs attributable to the passage of time, discount rates have to be used to convert both benefits and costs into present values in evaluations of public projects. More precisely, costs and benefits occuring in

future years are multiplied by a discount factor $(\frac{1}{1+i})_j$ where i is the social discount rate per year and j is the index of the year in which the cost or benefit will occur. As j becomes larger, that is, the more remote in the future the benefits and costs are, the smaller the discount factor and hence the present value of costs and benefits.

Economists do not agree on the appropriate social rate of discount. Two theoretical approaches exist, namely, the opportunity cost of capital and the social rate of time preference, which is lower. In Canada the social discount rate of 10 percent has been estimated(11) and this is the rate recommended by Treasury Board for benefit-cost analyses performed by federal departments and agencies(12). This is the rate which will be used in this study.

Applications in the Animal Health Field

Benefit-cost analysis has been used extensively in the field of public health and a considerable body of literature has accumulated over the last 30 years. However, in the field of animal health, it is only in recent years that "formal" benefit-cost analysis and other quantitative methods have been applied. Moreover, many of the studies employing benefit-cost analysis were undertaken by government agencies and thus remained unpublished.

Most of the early economic studies dealt primarily with the estimation of annual monetary losses from animal diseases without any estimation of the benefits from a specified control program to reduce these losses. One of the first good studies published in the area of animal disease economics was undertaken by Power and Harris in the aftermath of the 1966-67 epidemic of foot and mouth disease (FMD) in Great Britain(13). The authors employed the principles of benefit-cost analysis for evaluating alternative FMD control policies. Subsequently there have been a number of good benefit-cost studies undertaken both in the United Kingdom and the United States(14).

The use of benefit-cost analysis in the animal health field in Canada has been limited. O'Riordan in 1980 authored a study on an economic evaluation of alternative programs to control brucellosis in Canadian cattle(15). Kirk (1982) looked at the potential impacts of an outbreak of african swine fever in Canada(16).

Economic studies related to anaplasmosis are limited and are mainly concerned with an estimation of the economic loss associated with anaplasmosis. In a study conducted in California based on questionnaire surveys and personal interviews with veterinarians, ranchers and farm livestock advisors, it was estimated that in 1976 the economic loss in

the California beef cattle population due to anaplasmosis was $5,244,000[17].

A study conducted in the state of Texas found that the sum of losses due to anaplasmosis and cost of treatment and prevention costs resulted in an estimated total cost to Texas beef cattle producers equal to almost $9 million during 1982[18]. The study went on to estimate benefit-cost ratios of three control methods used, namely: (1) vaccination of cattle, (2) feeding a low level of chlortetracyline to cattle and thereby reducing Anaplasma marginale's ability to cause disease, and (3) control of biting insects (vectors). The results indicated that all three methods were cost effective.

4. Methodology and Data Requirements

Any economic evaluation of an animal health program basically involves calculating the benefits derived from the program and subtracting from those the costs of the program. The benefits may be derived from both additional revenue generated as a result of the program and costs no longer incurred or losses avoided as a result of the program. The costs may be composed of both expenditure on the program and revenue no longer received as a result of the program.

An important consideration in the economic evaluation is that all the relevant benefits and costs be included, while at the same time being careful to avoid double counting of any of

these. An example here is transfer payments which should not be included as this would involve double counting. The larger and more complex the animal health program, the more care has to be taken to avoid omitting any relevant benefits and costs. In public animal health programs, there are external benefits and costs, i.e., benefits accruing to and costs incurred by individuals or sectors of the community not directly involved in the program. In addition, some benefits and, on occasion, costs, may occur as extra-market or intangible benefits and costs; i.e., those for which a relevant market does not exist from which to derive a valuation, such as improved human health or reduced worry about the occurrence of disease. It is worth noting that public health programs such as eradication schemes are collective goods in the sense that everyone benefits from them regardless of whether they contributed to the scheme or were involved in it.

For a proper economic evaluation of an animal health program that avoids the omission of any relevant benefits and costs, a considerable amount of information is required. While the costs of a program are frequently easy to quantify and value, the benefits from a large scale animal disease prevention program may be less easy to quantify. In such cases it is necessary to predict the impact or effectiveness of the program and estimate the benefits to be derived.

Such predictions require a considerable amount of information, including the size and composition of the livestock population, the occurrence (distribution and prevalence) of the disease in the absence of the control program, the rate of spread (incidence over time and space) of the disease in the absence of the control program, and the impact of the control program on the disease. In calculating the impact of the disease, the number of affected animals and herds must be determined. In addition, estimates must be made of the detrimental effects of the disease through reduced production, mortality, reduced reproductive efficiency, and cost of treatment or prevention. In addition, the impact (if any) on trade must be considered. For example, if a disease such as foot-and-mouth were to break out in Canada, a number of countries would immediately ban imports of meat from Canada until one year after the disease is eradicated. This loss of export markets, as well as the resultant impact on the domestic market, would need to be estimated.

This study will estimate the impact of various possible control programs for anaplasmosis. The costs and benefits of each program will then be compared. The three control options to be evaluated are as follows:

1. Test and Slaughter

   This is the control program which has been used to combat all outbreaks of anaplasmosis to date. The costs of this

program include costs associated with surveillance, testing, depopulation(19), quarantine and indemnity payments. The data for this program will be drawn from the 1983 outbreak in Saskatchewan.

2. Test and Treat

This control option involves testing suspect animals and treating all animals with the disease with the drug oxytetracyline. The costs of this program include those costs associated with surveillance, testing, treatment and quarantine. Data from the 1983 outbreak as well as estimates of treatment costs will be used to estimate the costs of this policy option.

3. No Control Program

This option involves not combatting the disease publically. Under this option it is assumed that the disease would enter Canada and become established in certain regions of the country. The direct costs of this option will include physical losses in cattle which contract the disease, producers costs of treating infected animals and producers' costs of preventive control measures. In addition, it is anticipated that there will be additional costs as a result of requirements for testing of live cattle for export.

For this option costs will be estimated based on an economic study of the costs of anaplasmosis in the state of Texas.

These data will be adjusted, where necesary to reflect Canadian costs and Canadian experience with the disease. An estimate of the distribution and prevalence of the disease in Canada in the absence of a control program will be based on U.S. epidemiological studies of anaplasmosis, particularly in northern states, applied to the Canadian environment.

5. Case Review, 1983 Outbreak

Prior to evaluating the control alternatives it is instructive to analyze the 1983 outbreak in terms of epidemiological and environmental factors. The evidence from this outbreak is useful when looking at all three alternatives.

The outbreak was first detected in July 1983 following a visit by a veterinary practitioner to examine some dead and sick cattle on ranch 1, in the southwestern part of Saskatchewan. Ranch 1 is located in the Wood Mountain region of Saskatchewan, approximately 270 km south-west of Regina (See Figure 1). This area of the country can be classified as semi-arid, with the vegetation being composed mostly of short native grasses and sagebrush. There are practically no trees in the area. Very little of the land is cultivated. Ranching is the primary livelihood in the region and ranches tend to be large covering many square kilometers.

FIGURE 1

LOCATION OF ANAPLASMOSIS OUTBREAK AREA

Ranch 1 is a large operation composed of 24,000 acres (97 km^2) of range-land which is divided into two blocks. The south block borders along the U.S. border for a distance of 4 miles. At the time the outbreak was discovered ranch 1 had a cattle herd of about 1390 head as well as 315 sheep. The cattle were commercial beef cattle of mixed breeding (hereford, angus and shorthorn). Purebred bulls were used for breeding purposes.

The management practice of many ranchers in this region of the country can be characterized as traditional ranching. Cattle are turned out to graze on pasture from April to October/November. Little attention is paid to the cattle. For example, animals turned out in spring may not be seen again until branding time in June. Animal health care is not a priority in many of the ranching operations in the area.

The summer of 1983 was very hot and dry in the outbreak region. The insect population was characterized as being very heavy. Tick activity was at a high point as well as that of biting insects such as mosquitos and horn flies. These environmental factors likely contributed to the spread of the disease.

A number of factors, in addition to the high insect level, may have contributed to the spread of the disease. Fences in the region were generally in poor condition. On ranch 1 the fencing along the Canada/U.S.A. border was apparently non-existent. Stray cattle, especially yearling cattle, are a

problem in that they mix with neighbouring herds. It would not be uncommon for U.S. stray cattle to mix with Canadian cattle and vice versa. Stray cattle were found on ranch 30. It is often the practice to move cattle from one grazing area to another. This practice allows for the greater association of animals from different herds and thus promotes disease spread. Disease prevention measures such as sterilization of needles, castrating and dehorning instruments is often not practiced by operators. Furthermore, most operators do not practice insect control in this region. The lack of attention to health care on the part of some ranchers meant that the disease was able to spread and go undetected for a considerable period of time.

Certain geographic features of the area may have contributed to the spread of the disease. There are a number of creeks in the area which run across several different properties. Because of the water and the better grazing in these creeks and coulees, cattle would tend to spend much of their time in these areas. This factor increased the likelihood that neighbouring herds would come into close association along the fence line between the two properties.

An interesting case is the situation of herd 11, which had no animals that tested positively for anaplasmosis. This herd was completely surrounded by herds which had reactors. A factor which may have contributed to the herd being free of the disease is that rancher 11 used good management practices. His

fences were in good condition and insect control was practiced through the use of insecticide coated back-rubbers. One other factor is the fact that no major streams crossed this ranch.

Information obtained from the bordering state of Montana indicated that in the area directly south of the outbreak area anaplasmosis was a major problem. This area is similar in character to the outbreak area as it is ranching country. In the area of Montana slightly to the east of the outbreak area there was a very low incidence of the disease. What is different about this area is that it is a mixed farming area.

From the available evidence it is believed that anaplasmosis had been a clinical problem on ranch 1 for two years and in fact, may have existed there for 4-6 years. There is some evidence to suggest that anaplasmosis was clinically present on ranch 30 for one year. The cause of the outbreak in Saskatchewan has not been established but the problem with stray cattle is the most likely explanation. Given that the disease has been present in Montana for many years, it is not known why the disease had not emerged in the region before.

Table 1 presents data from the outbreak on those herds which had reactor animals. In total 120 herds were tested for anaplasmosis of which 17 herds contained reactor animals. Herds 1 and 30 had the largest number of sick animals. Both ranches 1 and 30 border on the U.S. border. The total number

TABLE 1

DATA ON HERDS INFECTED WITH ANAPLASMOSIS

HERD NO	HERD SIZE	NUMBER OF RETESTS - number -	REACTORS	ANIMALS SLAUGHTERED
Cattle				
1	1,389	5	725	982
2	231	4	39	47
3	313	1	12[1]	23[1]
4	220	1	2	2
10	637	4	55	65
12	739	1	11	14
14	249	1	4	7
19	161	2	10	13
20	189	1	3	5
28	729	1	8	9
30	564	4	195	267
32	1,191	0	1	1
35	403	1	2	2
45	520	1	3	5
49	597	3	23	33
56	170	0	1	2
TOTAL	8,368		1,094	1,477
Sheep				
1	315	1	89	90
41	134	1	11	11
TOTAL	449		100	101

1 Includes one goat

of animals sent for slaughter (marked-out) were 1476 cattle and 101 sheep and 1 goat. From the table, 383 more cattle were sent for slaughter than were reactors. This is explained by the fact that young calves were sent to slaughter with the mother cow even if the calves were not reactors. This was necessitated by the circumstance that the calves would not have survived on the range without the mother cow. Facilities were not available in the area to care for the young calves, consequently, the situation dictated that they accompany the cows to the slaughter house. Anaplasmosis does not cause clinical symptoms in sheep or goats, however, they can act as carriers of the disease and transmit it to cattle. Consequently, it was necessary to mark-out all reactor sheep or goats.

The last ranch under quarantine, ranch 1, was released from quarantine on February 9, 1984. While this marked the end of the quarantine period, it does not necessarily mean the outbreak is over. Testing will be conducted in 1984 and beyond in the outbreak area to ensure that the outbreak was completely eradicated.

6. Control Alternatives and Results

In this section the three control options will be evaluated separately in detail. The mechanics of each strategy will be described followed by an evaluation of the costs involved.

6.1 Eradication, Test and Slaughter

This is the strategy which was used to control all outbreaks of anaplasmosis in Canada. The most recent outbreak will be assumed to represent a "typical" outbreak which may occur in Canada from time to time in the future. The first two outbreaks of anaplasmosis in Canada resulted from imports of diseased animals which escaped the border inspection checks. They were imported into areas where the factors (mainly presence of suitable vectors) would not have lead to a rapid spread of the disease. The most recent outbreak was different in that it resulted from a northward movement of the disease into a region of Canada where the disease would spread and prosper if not controlled because of favourable factors (presence of ticks, range cattle). Accordingly, the size of this outbreak may be more typical of future outbreaks of the disease and the appropriate size against which control strategies should be evaluated. Consequently, data from the most recent outbreak will be used with the assumption that it represents a "typical" outbreak.

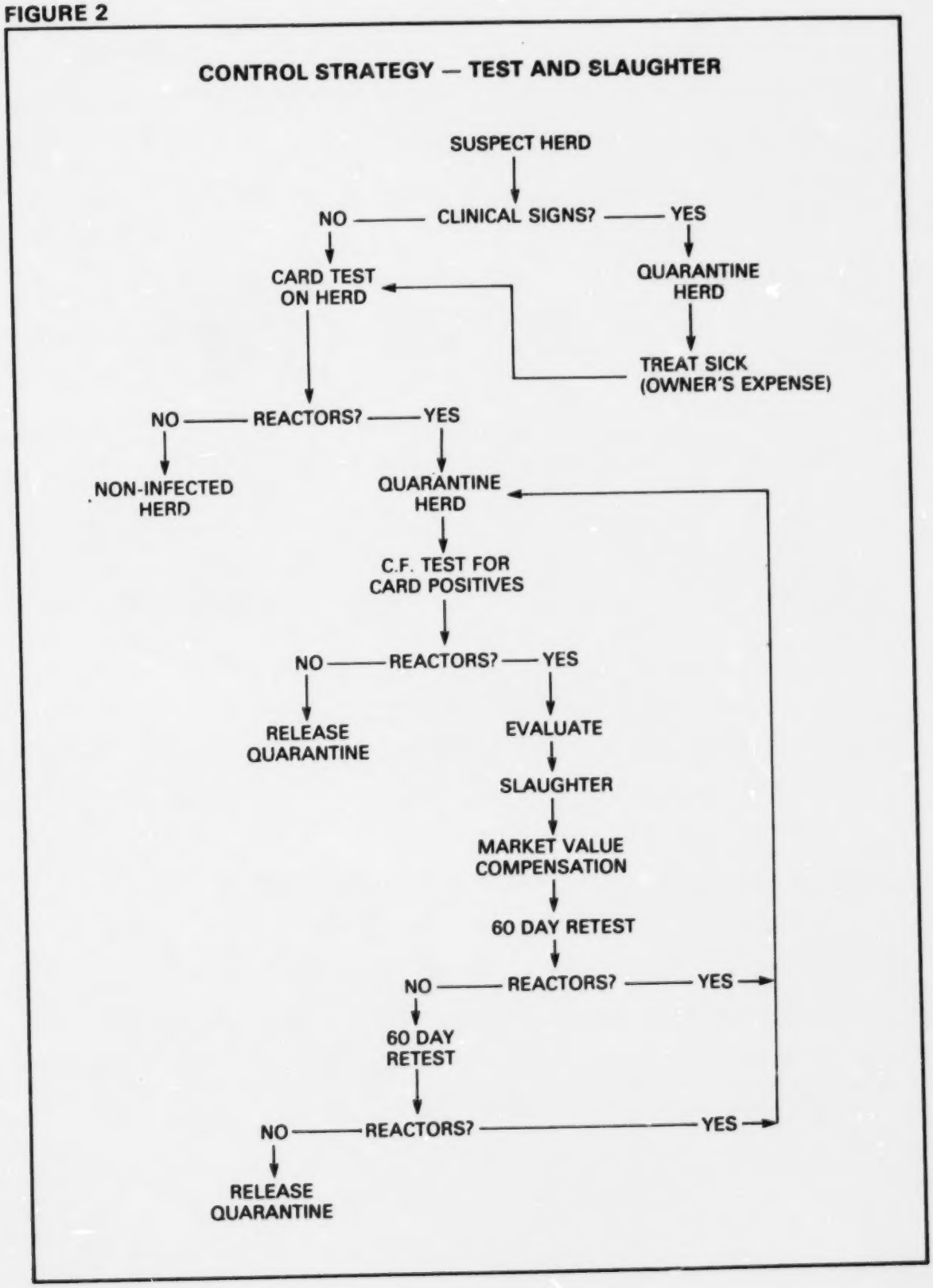
Control Practice

An outbreak of anaplasmosis is usually first detected by a veterinarian who would report the suspected outbreak to the nearest veterinary inspector of the Department of Agriculture. In the case of the most recent outbreak the private practitioner sent blood samples from ranch 1 to the

provincial veterinary laboratory. The blood samples gave a positive test for anaplasmosis and the laboratory immediately alerted the veterinary inspector. This sets in motion the control strategy as diagrammed in Figure 2. The suspect herd is visited by the veterinary inspector. If any animals show clinical signs the herd is quarantined immediately. Otherwise, the herd is tested using the anaplasmosis card test. If any animals react positively to the card test then the herd is quarantined. A blood sample for each suspect animal is sent to a laboratory for a confirmatory test by complement fixation test. Animals in the herd which show a positive test reaction are sent for slaughter directly and the transport vehicle is cleaned and disinfected. Market value compensation is paid for all animals sent for slaughter. After approximately 60 days the herd is retested in order to determine if any additional reactors developed. If so, then those animals are also sent for slaughter. Retests are conducted approximately every 60 days until two successive tests reveal no reactors. Once this occurs the herd is released from quarantine.

Each perimeter herd to the quarantined herd is also tested. If there is evidence to suggest that infection exists then that herd is immediately quarantined as well. The quarantine perimeter is expanded until no new herds with infected animals are detected. In the case of a large

FIGURE 2


CONTROL STRATEGY — TEST AND SLAUGHTER
SUSPECT HERD
CLINICAL SIGNS?
NO
YES
CARD TEST ON HERD
QUARANTINE HERD
TREAT SICK (OWNER'S EXPENSE)
REACTORS?
NO
YES
NON-INFECTED HERD
QUARANTINE HERD
C.F. TEST FOR CARD POSITIVES
REACTORS?
NO
YES
RELEASE QUARANTINE
EVALUATE
SLAUGHTER
MARKET VALUE COMPENSATION
60 DAY RETEST
REACTORS?
NO
YES
60 DAY RETEST
REACTORS?
NO
YES
RELEASE QUARANTINE

scale outbreak samples from marketed animals at nearby salesyards are taken and tested in order to determine if the disease is more widespread.

Control Costs

The direct costs in eradicating the outbreak in Saskatchewan are summarized in Table 2. The total cost of eradicating the 1983 outbreak was $990 thousand. From the table it can be seen that the largest portion of the cost is the net compensation cost of $635 thousand (64.1% of the total cost). Net compensation is the total compenstation less the salvage value of the animals (See Table 3). Compensation costs will be discussed more fully in the next section.

After compensation costs, salary costs represent the next largest cost. A further breakdown of these costs is presented in Table 4. The salary costs were incurred in two regions, Saskatchewan and Ottawa. The costs in Saskatchewan are associated with directly controlling the outbreak. The salary costs in this region were $169 thousand (17.1% of total cost). In Saskatchewan 41 different people had some involvement with the outbreak and they worked for a total of 923 days.

TABLE 2

OUTBREAK COST SUMMARY[1]

	Amount	Per Cent of Total
Salary (Regular and overtime)		
- Veterinarian	$ 66,329	
- Inspector	92,328	
- Other	9,956	
TOTAL	$168,613	17.0
Travel and Related	56,764	5.7
Materials and Supplies	17,939	1.8
Incidental	16,639	1.7
Laboratory Services	50,868	5.1
Headquarters Administration (Salary)	43,382	4.4
Net Compensation	635,483	64.2
TOTAL	$989,688	99.9

1 The cost includes all direct costs in controlling the outbreak from the discovery of the outbreak on July 12, 1983 to approximately February 9, 1984, the end of the quarantine period. Monitoring costs subsequent to the lifting of the quarantine are not reflected in this table.

TABLE 3

COMPENSATION COSTS

	NUMBER	COMPENSATION PAID	AVERAGE COMPENSATION PER ANIMAL	SALVAGE VALUE	NET COMPENSATION	SALVAGE VALUE/ COMPENSATION %
a) CATTLE						
- Cows	601	$505,100	$840.43	$157,298	$347,802	31.1
- Heifers	229	139,950	611.13	86,544	53,406	61.8
- Steers	85	48,745	573.47	43,425	5,320	89.1
- Bulls	36	70,315	1,953.19	22,142	48,173	31.5
- Calves	535	192,600	360.00	18,880	173,720	9.8
b) SHEEP						
- Adult	88	7,930	90.11	2,173	6,862	24.1
- Young	13	1,105	85.00			
c) GOAT	1	200	200.00	Nil	200	-
TOTAL	1,588[1]	$965,945		$330,462	$635,483	34.2

1 This total does not agree with the total number of animals slaughtered as shown in Table 1 by 10 head of cattle in that compensation was paid on these animals but they died prior to being sent for slaughter.

TABLE 4

SALARY COST SUMMARY

	NUMBER	WORKING DAYS	SALARY REGULAR	SALARY OVERTIME
Saskatchewan				
Veterinarian	11	268	$ 44,997	$21,332
Inspector	24	514	54,658	37,670
Other	6	141	8,827	1,129
Headquarters (Ottawa)				
Veterinarian	12	178	37,427	
Other	6	65	5,955	
TOTAL	59	1,166	$151,864	$60,131

In Saskatchewan, the veterinarians' time was mainly involved in activities at the outbreak area, such as doing the testing, arranging for tests and public relations activities with producers and press. The function of inspectors during the outbreak was to collect blood samples, assist the veterinarians, mark-out positive reactor animals, arrange for tests and conduct various other tasks at the outbreak site. The other category refers to clerical and secretarial services.

The general administration of the outbreak was conducted from Ottawa at an estimated salary cost of $43 thousand (4.4% of total). This involved a total of 18 different people working for 234 days. The total salary cost to control the outbreak was $211,995 (21.5% of total costs), involving 59 persons working for a total of 1166 days. This represents 4.7 person years.

Laboratory testing costs, using the complement fixation test, were $51 thousand. In total 31,400 samples were tested at an average cost of $1.62 per sample. Of the total number of samples 23,500 (75%) were obtained from cattle markets across the three prairie provinces. The samples collected were part of the normal market cattle testing program for brucellosis and tuberculosis and consequently the additional costs for collecting these samples was minimal. These samples essentially represented

the surveillance program to determine if the disease was more widespread. Testing at auction markets and slaughter houses identified 47 suspect cattle from 37 owners in Saskatchewan. Follow-up testing only revealed one herd which had anaplasmosis and this herd was one of the herds in the outbreak region.

There were a number of other small costs involved as shown in Table 2. Travel and related costs (accommodation, gasoline, oil, repairs) accounted for $57 thousand (5.8%). Materials and supplies (tags, blood vials, needles, test kits, etc.) accounted for $17 thousand (1.8%). Finally, incidental expenses (freight, telephones, printing, laundry, brokerage fees, rentals, miscellaneous) were $17 thousand (1.7%).

The above costs represent the identifiable direct costs of combatting the outbreak. There are a number of indirect costs which could be considered as part of control costs and consequently could be added to the final control cost outlined above. However, in evaluating these various indirect costs it was determined that for one reason or another no additional costs should be assigned to the outbreak costs discussed above. A discussion, however, of these various indirect costs is appropriate.

The first indirect cost considered is the time spent by herd owners providing assistance during herd testing. While this is a valid cost of individuals' leisure time, it could be argued that it had no effect on their output. Furthermore, it may be noted that the herd owner derives some offsetting benefits in having his herd tested for free, as well as getting free advice from a veterinarian. Consequently, it will suffice to say that an indirect cost exists here but the significance and net value is difficult to estimate and will not be done so here.

Another indirect cost which could be assigned as part of the anaplasmosis control program is the control of imports through the requirement of testing prior to importation. It is, however, difficult to ascertain what, if any, additional cost of border control should be attributed to anaplasmosis. The program for the prevention and detection of disease entry was primarily instituted to control the importation of major diseases such as foot-and-mouth disease. It can be argued, therefore, that the marginal (extra) cost attributable to the border control of anaplasmosis is negligible as the program costs would be the same with or without the existence of anaplasmosis in the world.

An indirect cost which is present but not believed to be significant is welfare loss. Welfare losses would

represent the net economic loss to society as a result of prices shifting away (price increases) from what they otherwise would have been, due to the effects of herd depopulation. However, because of the small depopulation relative to the total market, welfare losses are believed to be very small.

Two other costs which should be considered here are ongoing monitoring costs and research. Monitoring costs relate to surveillance following the final control of the outbreak to ensure that an outbreak does not flare up again. Surveillance involves testing of herds in the outbreak region subsequent to the lifting of the quarantine to ensure that no new reactors show up. In addition, it involves testing of blood samples obtained at auction markets and slaughter houses to ensure that any new cases of anaplasmosis are quickly detected. These monitoring costs are not yet available, however, they are not expected to be very large. Research costs relate to any public research projects undertaken to improve understanding about the disease and the ability to accurately detect the disease. The monitoring and research costs are not readily available. This is not a serious problem for this study as both of these two costs would also be present in the other two options considered. In the case of the test and treat option, the monitoring and research costs would not be very different from the test and slaughter option. In the case

of the no control option it is highly likely that a periodic monitoring of the level of the disease would take place as it does now in the United States. Furthermore, research would take place on how to control the disease. While these costs under the no public control option would not be the same as under the other two options, it is reasonable to assume that they would be similar. Consequently, the exclusion of monitoring and research costs is not serious as they are not large and, as they are in each option considered, the relative costs of each option will not be affected, only the absolute costs.

Compensation

How compensation is determined and what it represents is an important issue which will be treated here in some detail. The Animal Disease and Protection Act provides the authority to have an animal destroyed if it is affected with or suspected of being affected with an infectious or contagious disease. The Act further provides that compensation may be paid to owners whose animals are ordered destroyed. The Act specifies that compensation paid shall be the market value that the animal would have had immediately before destruction if it had not been subject to destruction under the Act. This is interpreted to mean what the animal would have been worth if it was traded had the animal not been classified as diseased. The Act provides for certain maximum levels of compensation to be specified by regulation.

The compensation costs have been included as part of the cost of the control program. Strictly speaking, however, compensation is not a cost of the program but is merely a transfer payment from one group in society (general taxpayers) to another (owners of destroyed animals). The fact that compensation is paid does not affect the economy's production possibilities, but it does alter society's income distribution. The true measure of the cost of the program is the loss of production that results because of the presence of the disease. In the case of anaplasmosis, the meat from slaughtered animals is perfectly safe for human consumption. Production losses here relate to the difference in value of an animal which can be used for breeding purposes versus the value of the animal for slaughter purposes, in the condition at the time it is sent for slaughter. Production losses can be closely estimated by taking the compensation paid for an animal and subtracting the carcass salvage value of the animal to come up with what shall be termed as net compensation costs. The carcass salvage value is the amount which a meat packing plant pays to Agriculture Canada for the animals sent to it for slaughter.

Compensation costs for the 1983 anaplasmosis outbreak are summarized in Table 3. In total 1588 animals were slaughtered with a total compensation cost of $965,945. The salvage value of these slaughtered animals was $330,462 for a net compensation cost of $635,483.

In determining the compensation value of an animal a number of factors were taken into consideration. These factors included:

1) type and age of animal;

2) condition of animal (fleshing, size, breed, soundness);

3) whether the producer had a breeding program and performance records;

4) in the case of purebred animals the pedigree is considered; and

5) in the case of animals which were visibly sick, they were valued as if they were not diseased.

The average compensation value for cows, from Table 3, was $840. The compensation value for cows was essentially determined by taking their slaughter value and adding on a premium based on the breeding value of the animal. This premium ranged from $0 for cows with obvious physical problems up to about $300, depending on age and genetic background of the animal. At the time of year when the outbreak occurred 95% of the animals would be considered as breeding stock as all the cows had been placed on the pasture to be bred.

The average compensation value for steers of $573 per animal was based on the current market price. Heifers, however, were evaluated as breeding animals as they were in breeding pastures with bulls to be used in the cow herd as replacements. From $100 to $150 was added to the feeder cattle value of heifers in order to take into account their value as breeding stock. This fact explains why the average compensation value for heifers of $611 exceeds that of steers.

The average compensation for bulls was $1,953. These animals were all purebred and used for breeding purposes. The value of these animals happened to be slightly below the average for the region as included was a high proportion of yearling bulls of unproven breeding potential. It is estimated that the average price of mature bulls in the area would range from $2000 to $2500.

In economic terms the compensation paid on all types of animals accurately reflected the loss in production possibilities. It bears repeating again that while the term compensation is used, it is really the production losses which are being estimated in determining the cost of the outbreak.

It is interesting to examine the salvage value in comparison to compensation paid out. For the 1983 outbreak

the salvage value represented 34.2% of compensation paid. By way of comparison, salvage value as a percent of compensation for the 1968 outbreak in Manitoba was 48.3%. For the 1979 outbreak in Quebec it was 16.0%. It thus appears that salvage values are typically low.

There are a number of factors which explain the low salvage value. In the case of cows, heifers and bulls these animals were valued as breeding stock which is above the meat price of the animal. In addition, some of the cows and bulls were clinically sick and as a result had lost weight, yet they had been compensated for as if they had been healthy. Another factor was the temperature which averaged over 38°C at the time of the outbreak. Between the time the animals were evaluated for compensation and transported to the nearest slaughter point, about 160 km away, the heat and the stress would have resulted in some conditioning and weight loss. The salvage value for calves was extremely low (9.7% of compensation paid). The reason for this was that at the time of the outbreak the calves were very young, composed only of skin and bones and consequently too light to qualify as veal calves. For many of the calves there was no salvage value as the carcass had no value.

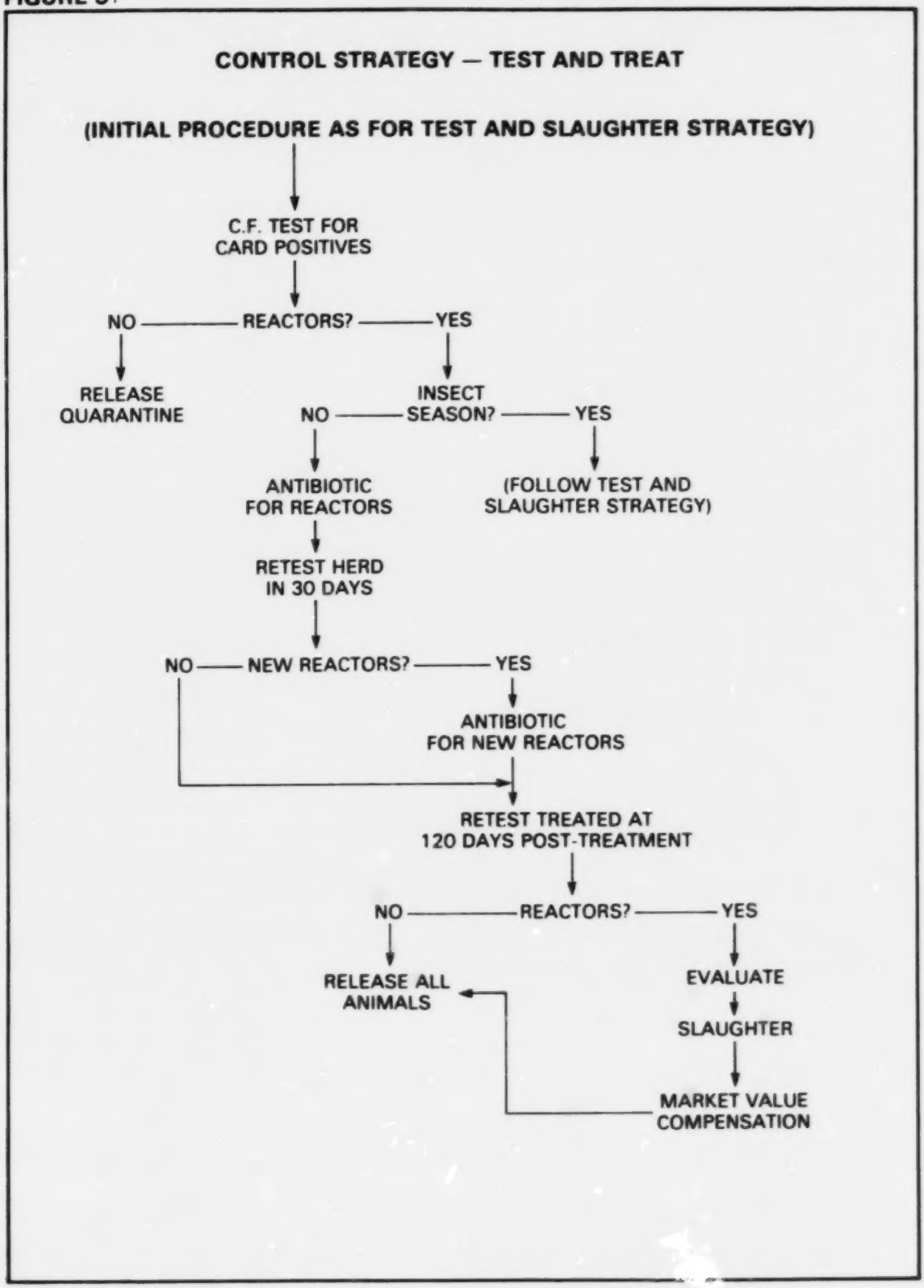
Another factor which may have contributed to a low salvage value is the "monopoly" position which the nearest

slaughter house enjoyed. The nearest slaughter house was used out of necessity as shipping to potentially more competitive distant markets would have increased the risk of spreading the disease. The extent, if any, to which the slaughter house was able to earn excess profit on these animals means that the production loss as measured by the net compensation is overstated. It represents, in effect, a transfer payment from taxpayers to the slaughter house.

6.2 Eradication, Test and Treat

The test and treat control strategy is very similar to the slaughter strategy except that instead of slaughtering reactor animals they are treated with antibiotics. The procedure of this strategy is outlined in Figure 3. The initial test procedure is the same as for the slaughter policy. The key decision factor as to whether this strategy can be used to eradicate the disease is whether vectors (ticks and biting insects) are still active. Research indicates that treatment initiated while vectors are still active will fail to eliminate the carrier state[20]. It is generally only safe to use this strategy after the first killing frost. This fact severely limits the applicability of this strategy. Outbreaks will occur only when vectors are active. The usual season for the tick is from the end of March until early July. Clinical signs of anaplasmosis are mainly observed during the months of July, August and September. Once an outbreak is

FIGURE 3.


CONTROL STRATEGY — TEST AND TREAT
(INITIAL PROCEDURE AS FOR TEST AND SLAUGHTER STRATEGY)
C.F. TEST FOR CARD POSITIVES
NO
REACTORS?
YES
RELEASE QUARANTINE
INSECT SEASON?
NO
YES
ANTIBIOTIC FOR REACTORS
(FOLLOW TEST AND SLAUGHTER STRATEGY)
RETEST HERD IN 30 DAYS
NO
NEW REACTORS?
YES
ANTIBIOTIC FOR NEW REACTORS
RETEST TREATED AT 120 DAYS POST-TREATMENT
NO
REACTORS?
YES
RELEASE ALL ANIMALS
EVALUATE
SLAUGHTER
MARKET VALUE COMPENSATION

discovered time is of the essence as while insects are active the disease will continue to spread. Therefore, it will usually not be feasible to hold animals until the insect season is over in order to use the treatment strategy. Nevertheless, this strategy can be compared, on a cost basis, to the slaughter option for those reactors detected after the end of the vector season.

The treatment option is based on the finding that treatment with the antibiotic oxytetracycline is successful in eliminating the acquired carrier state of anaplasmosis in cattle[21]. Under this control option, once the insect season is over it may be used. The first step of the treatment procedure is to inspect the animals to ensure that they are tick free. The reactor animals are then injected intramuscularly with long-acting oxytetracycline at the rate of 20 mg/kg body weight. This is repeated at 3 to 4 day intervals until 4 treatments have been given. The treated animals are retested 120 days following the last treatment. If the test is negative the animal is released from quarantine, if the test is still positive the animal is sent for slaughter and compensation is paid.

The test and treat control strategy has not been used in the eradication of anaplasmosis outbreaks. The primary reason for this is that the Animal Disease and Protection Act does not provide for the payment of treatment costs. Under present circumstances the herd owner would have to pay for treatment costs. As a herd owner is fully compensated under the test and slaughter option, he would have no incentive to pay for treatment costs himself. For the purposes of evaluating this option, however, it will be assumed that all treatment costs are provided for under the Animal Disease and Protection Act.

In examining the test and slaughter and the test and treat strategies it appears that the two procedures are almost the same except that in one case the reactor animals are treated while in the other they are slaughtered. Therefore, the cost of controlling an outbreak should be the same under both strategies except for the cost of compensation versus the cost of treatment. As the test and treat option was not used in the Saskatchewan outbreak, no data are available as to the cost of this option. However, it is estimated that the cost of treating an average reactor cow is $50. This is based on a drug (oxytetracycline) cost of $20 to treat a 500 kg animal and additional labour costs of $30. If it had been feasible to treat all 1194 reactor animals in the Saskatchewan outbreak, the cost would have been $59,700. This compares

with a net compensation cost of $635,688. Consequently, had it been possible to treat all animals the savings would have amounted to $575,988. This would have represented a saving of 58.2% in the Saskatchewan outbreak.

As has been noted, the test and treat strategy is only considered effective after the first killing frost has eliminated the vectors. In the 1983 outbreak the first killing frost did not occur until October 15. The normal date for the first hard frost in the area is about September 15. After October 15, 1983 only 75 reactors were identified and 105 animals were sent to slaughter. If these 75 animals had been treated the treatment cost would have been $3,750. The net compensation for the slaughtered animals, assuming they were of average type, was $42,232. Thus the availability of the test and treat option would have resulted in a saving of $38,482, or 3.9% of the total outbreak cost. Therefore, under the circumstances of the 1983 outbreak, the possible savings had the test and treat option been available, would have been very small.

It should be noted that the calculations, under this option, were made assuming that 100% of treated animals lose their anaplasmosis carrier state. In a test and treat program conducted in northern Idaho and soutwestern Washington 110 infected cattle were orally treated with antibiotics and all animals became sero-negative (gave a

negative anaplasmosis test) following treatment[22]. Thus for calculation purposes it is reasonable to use the 100% assumption, however, it is also reasonable to assume that in a large scale test and treat program, a small number (possibly less than 1%) of treated animals will not lose their carrier status or will give a false negative test. To the extent that this occurs, this will increase the cost of the test and treat option.

The implications from the results are that potential savings could be realized if the test and treat option could be used. The earlier in an outbreak that this strategy can be adopted, the greater the savings in control costs. A question which should be examined is how early before the end of the vector season this strategy can be successfully employed to eradicate the disease. Research in this area would be very useful.

6.3 Endemic Anaplasmosis, No Public Control

Under this option the assumption is made that Canada completely abandons public control of anaplasmosis. It is assumed that the disease would enter Canada and gradually establish itself in certain regions of Canada. The rate of spread of the disease is not known but it is believed that this process would be slow, perhaps taking some ten years or more. At a certain point in time it is hypothesized that the disease would reach a "steady state" where it

would not move into new areas as natural factors would prevent this.

Figure 4 provides an estimate, by census districts, of where anaplasmosis would establish itself in the cattle population. Furthermore, these districts are ranked as to high, medium and low depending on the projected incidence level of clinical cases of anaplasmosis[23]. As can be seen from the map, the area of high incidence level includes census divisions 3 and 4 in southwestern Saskatchewan and census division 1 in southeastern Alberta. A band of medium level (census divisions 2, 7 and 8 in Saskatchewan and 2 and 4 in Alberta) and low level (census divisions 1, 6, 11, 12 and 13 in Saskatchewan and 3, 5 and 7 in Alberta) incidence surrounds the high level area.

A number of factors were taken into consideration in determining where anaplasmosis would establish itself. The first factor is the prevalence of the tick Dermacentor andersoni. The second factor is the presence of sagebrush and open rangeland. This type of terrain supports mainly ranching operations which are conducive to the establishment and spread of the disease. In addition, anaplasmosis is known to be present just south of this region, in the state of Montana. It is possible, in fact highly probable, that outbreaks of anaplasmosis would occur in Canada in regions outside of the one indicated,

FIGURE 4

POTENTIAL INCIDENCE OF ANAPLASMOSIS BY CENSUS DISTRICTS

High Incidence

Medium Incidence

Low Incidence

generally resulting from the importation of a carrier animal into the area. However, it is believed that the chances of anaplasmosis becoming endemic in any other region is low. It is felt that environmental factors would not be conducive to the disease in these areas and that private control practices may eradicate the disease in these instances. Consequently, for this study, the costs of isolated outbreaks outside of the region in question will be assumed to be small and will be ignored.

For the purposes of calculating economic costs of the no public control option, the assumption is made that anaplasmosis has become fully established in the region indicated in Figure 4. In order to determine economic losses which would be attributable to anaplasmosis the following average incidence level of clinical cases is assumed in these regions: high incidence area - 1.5%, medium incidence area - 0.15%, and low incidence area - 0.015%. These levels were estimated based on a 1980 survey conducted in Texas[24]. In that study the number of clinical cases in the high incidence area was 1.23%, in the medium incidence area it was 0.076% and 0.016% in the low incidence area. The authors of the Texas study felt that 1980 was a low incidence year compared to previous years. Available evidence from Montana suggests that these values are not inconsistent with the level in that state. It should be noted that the clinical incidence levels assumed

are representative of an average year. The U.S. experience with the disease suggests that the clinical incidence level fluctuates from year to year with occasional heavy losses occurring. For example in 1964 in the state of Montana it was estimated that a death loss of 7% of cattle as a result of anaplasmosis occurred in most herds[25].

Using the incidence levels assumed and the cattle population derived from the 1981 census, an estimate is made of the number of cattle which would show clinical signs of the disease, each year, if the disease was endemic to Canada. These results are shown in Table 5. From the table, the number of clinical cases of anaplasmosis per year is estimated to be 4,710. It is estimated that of these 4,710 animals, 1695 would die and a further 844 would be chronic cases (cases in which animals do not regain their weight after three months of illness). Furthermore, 730 fewer calves would be produced by these sick animals. This reduced calf crop is due to an increased number of abortions and a lower conception rate amongst sick animals. The proportion of death, chronic cases and abortions among clinical cases is derived from the Texas study.

The estimated economic losses associated with the clinical cases are presented in Table 6. The results indicate that if anaplasmosis were endemic to Canada that the yearly losses would be $2.5 million. The largest portion of these

TABLE 5

ESTIMATE OF THE NUMBER OF CATTLE AFFECTED
SHOULD ANAPLASMOSIS BECOME ENDEMIC IN CANADA

RISK AREA[1]	CATTLE POPULATION[2]	CLINICAL CASES[3]	DEATHS[4]	SURVIVORS[5]	CHRONIC CASES[6]	ABORTIONS[7]
a) HIGH						
- Cows[8]	242,883	3,643	1,311	2,332	653	257
- Bulls[9]	13,455	202	73	129	36	257
b) MEDIUM						
- Cows	494,296	741	267	474	133	52
- Bulls	19,532	29	10	19	5	52
c) LOW						
- Cows	598,718	90	32	58	16	6
- Bulls	35,987	5	2	3	1	6
TOTAL						
- Cows	1,335,897	4,474	1,610	2,864	802	315
- Bulls	68,974	236	85	151	42	315

1 Risk areas were assigned based on the probability of maintaining and propagating anaplasmosis for a long period of time. The high risk area is made up of census divisions 3 and 4 in Saskatchewan and division 1 in Alberta. The medium risk area is composed of census divisions 3, 7 and 8 in Saskatchewan and 2 and 4 in Alberta. The low risk area is composed of census divisions 1, 6, 11, 12 and 13 in Saskatchewan and 3, 5 and 7 in Alberta.

2 Source: Statistics Canada, 1981 census.

3 Clinical cases are those cases where the animal exhibits observable symptoms of the disease. The incidence level of clinical cases in adult cattle was assumed to be 1.5% in the high risk area, 0.15% in the medium risk area and 0.015% in the low risk area.

4 The death rate is taken to be 36% of the number of clinical cases.

5 Clinical cases minus deaths.

6 Chronic cases represent 28% of the survivors. Chronic cases are those cases in which the animals do not regain their weight after 3 months of illness.

7 An abortion rate of 22% among survivor cows is assumed. It is assumed that abortions are composed of an equal distribution (50%) of male and female animals.

8 All females over 2 years of age.

9 One year and over.

TABLE 6

ESTIMATED LOSSES ASSOCIATED WITH CLINICAL CASES OF ANAPLASMOSIS

CLINICAL CASES	No. OF CASES	LOSS VALUE PER CASE[1]	TOTAL LOSSES AND COSTS
Death loss			
Cows	1,610	$ 840	$1,352,400
Bulls	85	2,250	191,250
TOTALS	1,695		1,543,650
Survivors			
Chronic Cases			
Cows	802	390	312,780
Bulls	42	1,340	56,280
TOTALS	844		369,060
Abortions			
Heifer Calves	315	325	102,375
Steer Calves	315	375	118,125
TOTALS	630		220,500
Other Production Losses[2]			65,420
Cost of treatment and labour	4,710	60	282,600
TOTAL LOSSES AND COSTS			2,481,230

1 Value of cows was based on average compensation value. Value of bulls was based on estimated value of average bull. Value of calves was based on projected value of calves at fall marketing, from the compensation value. Chronic cases were valued based on 86 kg. weight loss by cows and 136 kg. weight loss by bulls plus the complete loss of breeding potential of these animals. The average estimated cost of treatment per clinical case of $60 is composed of $30 for drugs and/or veterinary service and $30 for labour and extra husbandry required to handle the case.

2 Other production losses include a lower weight gain for calves of sick cows and an increased cull rate for clinical cases, even though they have recovered. A 5% lower weight is assumed for calves of sick cows due to reduced milk production by the mother cow. A 6% higher cull rate is assumed for clinical cases, resulting in the loss of the breeding value of these animals.

losses, or $1.5 million (approximately 62%) would be attributable to the death of animals. The additional losses are made up of $369 thousand loss due to chronic cases (sick cattle that do not regain their weight), $221 thousand due to anaplasmosis induced abortions, $65 thousand due to other production losses and $283 thousand to treat the sick animals.

In this study no direct assignment is made for any economic loss to cases where the animal became sick but recovered in one to three months. It is assumed that any losses associated with these cases are captured by the losses due to abortions and other production losses, and treatment costs. This assumption differs from the Texas study which valued the weight loss of survivors as a dollar loss.

The Texas study also estimated the cost of measures used in that state to prevent the spread of anaplasmosis. The principal methods used are vaccination, low level feeding of chlortetracycline and insect control on cattle. The cost of preventative measures, as estimated in the Texas study, was approximately 40% of the physical losses. However, the Texas data are not believed to be applicable to the Canadian situation. The evidence from Montana indicates that herd owners in that state mainly treat only the sick animals (with injections of oxytetracycline). In herds were many animals are sick the adult animals are also

vaccinated. Vector control is rarely used and treatment in feed is seldom practical with range cattle. Based on the experience in Montana, it is estimated that any costs due to preventive measures (other than the treatment costs estimated in Table 6) would be small under the Canadian situation. Consequently, no additional costs will be assigned to preventive measures.

One additional cost which will be considered here is the possibility that cattle for export may have to be tested for anaplasmosis. Should anaplasmosis become endemic to Canada it is felt that the United States Department of Agriculture would not require that Canadian cattle be certified free of anaplasmosis. However, some states have regulations for controlling anaplasmosis and they may require that some or all imported Canadian cattle be certified free of anaplasmosis. In addition, exports to South Korea and Japan will likely have to be certified free of anaplasmosis. Normally the cost is borne by the herd owner in the exporting country. The states of Hawaii, Minnesota, Wisconsin, New York and Oregon require such certificates and in 1983 these states imported 110,249 head of cattle from Canada. Exports of live cattle to South Korea and Japan in 1983 totalled 9590 head. The additional cost to an owner for an anaplasmosis test is estimated to be $15 per animal (veterinarian and laboratory costs). If all of the 119,839 head of cattle had been required to be

tested for anaplasmosis, this would have meant an additional cost of $1,797,585. However, it is likely that only cattle imported for breeding purposes would be required to be tested, while those imported for slaughter would not. Of the live cattle exported to the United States, 8,571 head were for breeding purposes and the rest were exported for slaughter. All exports to Japan and South Korea would have to be tested. Therefore, it is estimated, using 1983 export levels, that 18,161 head of cattle would have had to have been tested for anaplasmosis prior to their exportation. Consequently, if anaplasmosis were to become endemic in Canada it is estimated that this would result in additional export testing costs in the order of $272,400.

In addition to export testing costs there is the possibility that additional testing costs may arise on sales within Canada. For example, purchasers of breeding stock who live in an anaplasmosis free area and who purchase animals in an endemic area may request that animals be certified to be free of anaplasmosis. To the extent that such practices develop, in lieu of public control, the costs of testing for anaplasmosis will be understated by this study.

In summary, the total yearly cost, should anaplasmosis be endemic to Canada is estimated to be approximately

$2.8 million, which is made up of the sum of $2.2 million direct losses due to anaplasmosis, $283 thousand in treatment costs and $272 thousand in additional export testing costs.

7. Evaluation of Control Alternatives

This section will summarize the benefits and costs to Canada from controlling anaplasmosis. The results are presented in Table 7 which includes the discounted present value of benefits and costs, net present value and the benefit-cost ratio for the two control options. The values are based on using a social discount rate of 10 percent and using an evaluation period (time between outbreaks) of 10 years.

The benefits of each control option are, in effect, the losses avoided should the disease become endemic. It is assumed that the $2.8 million estimated per year loss would occur each year for 10 years. This yields a present discounted value of $16.9 million. The costs of the two control options (as outlined in the previous section) are assumed to occur at the beginning of year 1 with no costs for the subsequent 9 years.

The results in Table 7 indicate a net present value (NPV) of approximately $16 million with both control options. The benefit-cost ratio for the test and slaughter option is 17.1:1. The feasible test and treat option yielded a benefit-cost ratio of 17.8:1. Had it been possible to treat all reactor animals

TABLE 7

EVALUATION OF CONTROL POLICIES IN TERMS OF DISCOUNTED NET PRESENT VALUES AND BENEFIT-COST RATIOS

POLICY	DISCOUNTED PRESENT VALUE[1] - thousands of dollars -		NET PRESENT VALUE[2]	BENEFIT-COST RATIO
	BENEFITS	COSTS		
1. Test and Slaughter	16,920	990	15,930	17.1
2. Test and Treat[3]				
- Feasible	16,920	951	15,969	17.8
- Potential	16,920	417	16,503	40.6

1 A uniform 10 percent annual discount rate was applied.

2 Net present value represents the discounted present value of benefits less the discounted present value of costs.

3 Feasible value is based on the use of treatment only after the end of the vector season. Potential value is based on the ability to successfully treat all infected animals.

the benefit-cost ratio would have been 40.6:1. These results clearly indicate that both control options are justified on the basis of a large net present value and benefit-cost ratio.

7.1 Sensitivity of Results

The results strongly support the proposition that eradicating outbreaks of anaplasmosis is preferable to allowing the disease to become endemic to Canada. This conclusion is based on a number of assumptions which may not be valid. The results in Table 7 represent, in effect, the most probable estimates based on the available information. In any evaluation of alternatives it is instructive to examine the sensitivity of the results and conclusions by assessing the data used and the assumptions made.

The cost data were obtained from the eradication of an actual outbreak and consequently can be considered to be fairly accurate. The benefits results, however, are based on a number of assumptions which should be examined for their reasonableness and sensitivity. The greatest uncertainty in this area lies in the estimation of losses should anaplasmosis become endemic to Canada. Two main assumptions had to be made, namely the area(s) in Canada in which the disease would become endemic and the incidence level in each area. The estimated endemic region was chosen based on the presence of the same ecological factors

as are present in the endemic regions of the state of Montana. Greater uncertainty lies in estimating the incidence level of the disease should it become established in Canada. The incidence level and losses estimated were based on a Texas survey. Unfortunately the climate and the epidemiology of the disease are different between Texas and Canada. However, data from more suitable states such as Montana are not available. What information is available from Montana suggests that if a survey were done in that state the incidence levels and consequent losses would not be vastly different.

In order to test the sensitivity of the conclusion to the incidence level assumption a calculation was made using an arbitrary "conservative" scenario. It was assumed that losses were only one-fifth of those indicated in Tables 5 and 6. Furthermore, it was assumed that there would be no additional testing costs for any export shipments and that a major outbreak of the size of the 1983 outbreak would occur every five years. Under this scenario, using a 10% social discount rate the calculated NPV of the test and slaughter option was $891 thousand and the benefit-cost ratio was 1.9:1. Thus even under this highly conservative benefits assumption the results still yield a positive NPV and a benefit-cost ratio greater than 1. This result lends considerable strength to the conclusion that publically controlling anaplasmosis is preferable to no public control.

One additional test of the sensitivity of the results is to perform the calculation using alternative social discount rates. Calculations were made for the test and slaughter option assuming a 5% and a 15% social discount rate. The results indicate a NPV of $20.3 million and a benefit-cost ratio of 20.5:1 using a 5% social discount rate and a NPV of $12.8 million and a benefit cost ratio of 13.0:1 using a 15% social discount rate.

7.2 Observations and Suggestions

A number of observations can be made based on the study. The first observation is that the frequency and size of future outbreaks of anaplasmosis will dictate the size of the net benefits of a control program. This observation suggests that the cost of the control program can be reduced through the prevention and early detection of outbreaks.

Prevention of outbreaks means the continuance of the present program of requiring certificates certifying that an animal does not have anaplasmosis. While the border control has missed two importations of anaplasmosis carrier animals, the outbreaks were not nearly as costly or large as the most recent one which resulted from a northward movement of the disease. The recent outbreak points to the need to examine preventative measures along certain border areas. The lack of proper fencing in certain border areas

increases the chances of movement of the disease across the border.

In addition to prevention, early detection of the disease will substantially reduce control costs. Anaplasmosis is a disease which does not appear to spread rapidly. Consequently, if the disease is detected at an early stage, before it spreads to neighbouring ranches from the originally infected ranch(es), the costs, both in terms of compensation and testing, will be much lower. A year marked with unusually high vector activity should signal the need for greater vigilance for the disease.

The study identified that, in the case of the most recent outbreak, poor herd management practices may have contributed to the size of the outbreak. A number of programs could be helpful in this regard. One such program would be the education of producers to be aware of animal diseases and the economic consequences of diseases. In the case of anaplasmosis this educational effort could be concentrated in the most susceptible areas. The use of a new technological advance, in the form of insecticidal ear tags, should be encouraged as a method of slowing the spread of any future outbreaks. In addition, it has been estimated that cattle production losses due to horn flies is approximately 16%[26]. It is believed that the use of the ear tags would reduce much of the 16% productivity loss.

The study identified the test and treat option, when feasible, as less costly than the test and slaughter option. Authority should be obtained under the Animal Disease and Protection Act to pay for treatment so that the opportunity exists to use this option. Given the potential cost savings which can be realized from using this option, research into how to implement this option would be useful. Such research might include determining the earliest feasible time during the vector season that the strategy could be successfully adopted, success rate of the treatment procedure and means to prevent re-infection of treated animals.

Finally, the study demonstrates that the lowest cost eradication scheme for anaplasmosis is a combination of the test and slaughter and the test and treat options. Under such an approach the test and slaughter program would be used while biting insects are still active and the test and treat option would be used after this time. Given that outbreaks of anaplasmosis will generally be detected in the summer months, this means that the test and slaughter route will be used first to control the outbreak. Thus reduction in control costs by use of the test and treat option will generally be small given the present limitation of use of this option to the non-insect season.

8. Summary and Conclusion

Anaplasmosis is a worrisome cattle disease in the United States and a number of other countries and this disease occasionally has made incursions into Canada. This study has estimated the impact of the disease in Canada, both in terms of the costs of controlling an outbreak and the costs should the disease not be publicly controlled.

The data for this study was mainly drawn from the 1983 outbreak of anaplasmosis in Saskatchewan. The control of this outbreak cost $990 thousand and resulted in the slaughter of 1588 animals. This latest outbreak was the largest and most costly to date by far.

The study estimated that if anaplasmosis was not controlled and the disease established itself in Canada the yearly losses to producers through death and sickness of animals, treatment and testing costs would be approximately $2.8 million. This one year loss is almost three times what it cost to eradicate the 1983 outbreak. The net present value and benefit-cost ratios were calculated for the two possible control options. The results indicate that public control of anaplasmosis is unquestionably justified.

The study went on to identify a number of steps which could be taken to minimize the risk of future outbreaks or to minimize the size and cost of the outbreak. One important step is that

authority be obtained under the Animal Disease and Protection Act to pay for treatment costs when it is feasible to use the test and treat option.

FOOTNOTES

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GLOSSARY OF TERMS

African swine fever - A highly contagious, usually fatal viral disease of pigs.

Anaplasma titres - refers to the level of anaplasma anti-bodies in blood serum.

Atony of the bladder - loss of tone of the muscular coat of the bladder wall.

Card agglutination test - a rapid diagnostic test which can be used in the field to indicate the presence of anaplasmosis.

Complement fixation test - a laboratory diagnostic test used for diagnosing anaplasmosis and other diseases.

Dermacentor andersoni - the Rocky Mountain wood tick found in Western or North Western U.S.A. and Canada. It is a three host tick with the larvae and nymphs feeding primarily on small mammals while the important hosts for the adult include cattle, horses, sheep, dogs, man and other large mammals.

Endemic - constantly present in a particular country or locality; said of a disease.

Epidemiological - all elements contributing to the occurrence or non-occurrence of a disease in a population; the ecology of a disease.

Foot-and-mouth disease - an acute, highly communicable viral disease chiefly confined to cloven-footed animals.

Mark-out - to designate with a tag and seperate out those animals to be sent for slaughter.

Opportunity cost of capital - the average rate of return to investment in the private sector.

Oxytetracycline - an antibiotic used for the treatment of infection caused by bacteria and protozoa.

Pallor - to be pale, lack of colour.

Reactor - an animal which has a positive diagnostic test result.

Rinderpest - an acute viral disease of cloven-hoofed animals, particularly cattle.

Serum - the clear, straw-coloured liquid portion of the blood in which blood cells are suspended.

Social rate of time preference - the rate at which society is willing to defer current consumption in exchange for increased consumption in future periods.

Vector - any agent which transmits a disease-producing organism from one host to another.

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